WIND GENERATORS:

Here's an advanced design you can build

Modern airfoils, new materials and techniques breathe fresh air into the old science of windpower

By HANS MEYER

Want to put the wind to work around your place—producing electricity for power tools, lighting, heating, or pumping? The wind generator being erected below can do the job, and you can build it for around $200. It won't supply 100-amp, 60-cycle juice for your home circuits, but it can be a fascinating trial of a non-polluting, independent power source fully capable of handling light-duty jobs such as those we've just mentioned.

The unique blade construction helps to beat the high efficiency/high cost, vs. low efficiency/low cost bugaboo that has plagued past designs. The blade is based on a sophisticated airfoil, but it's simple to make. So is the rest of the windmill. Basic design details:

- Three-blade rotor, 10 feet in diameter.
- Wooden tower 12 feet high.
- Output about 1/4 hp in 10-mph winds; two hp in 20-mph winds; six hp in 30-mph winds.
- Max efficiency in 10- to 12-mph wind at 110- to 115-rpm blade speed.

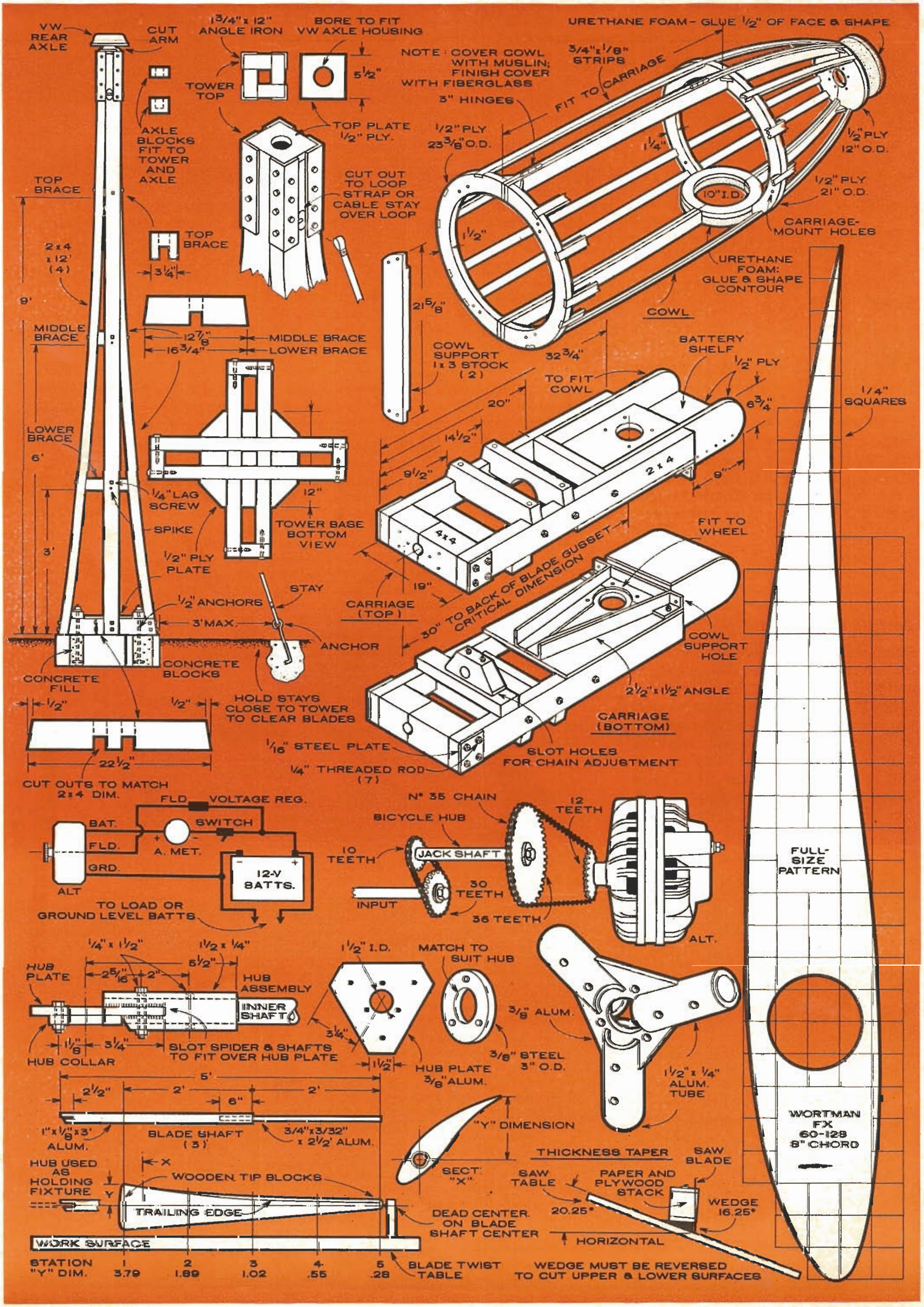
The generator appears to run backwards with its tail to the wind. This eliminates the tail vane; the cowling and blades combine action for alignment. The wood, cloth, and fiberglass cowling, centrally hinged to open for access, also houses the alternator and regulator plus two batteries used for excitation and minimal energy storage.

Tower design and placement are important. As shown, the tower offers little obstruction to the wind. Place it high enough above surrounding obstacles to avoid slowing the airflow or generating turbulence. To permit orientation to the wind, the carriage, cowling, and blades pivot on a junk VW rear wheel, hub, and axle.

Continued

About the author

Hans Meyer is a graduate engineer, one of the authors of Domebook 2, and the head of a Wisconsin commune called Windworks where he developed the wind-powered generator below. As we went to press, he was working with Bucky Fuller, installing a solar still and wind generator on Fuller's island off the coast of Maine.


VW REAR AXLE
CUT ARM
1 3/4" x 12" ANGLE IRON
BORE TO FIT VW AXLE HOUSING
5 1/2"
TOWER TOP
AXLE BLOCKS FIT TO TOWER AND AXLE
TOP PLATE 1/2" PLY.
CUT OUT TO LOOP STRAP OR CABLE STAY OVER LOOP
NOTE: COVER COWL WITH MUSLIN; FINISH COVER WITH FIBERGLASS
URETHANE FOAM - GLUE 1/2" OF FACE & SHAPE
3/4" x 1/8" STRIPS
FIT TO CARRIAGE
3" HINGES
1/2" PLY 23 3/8" O.D.
1 1/4"
1/2" PLY 12" O.D.
1/2" PLY 21" O.D.
10" I.D.
CARRIAGE-MOUNT HOLES
1 1/2"
URETHANE FOAM: GLUE & SHAPE CONTOUR
COWL
TOP BRACE
2 x 4 x 12' (4)
9'
TOP BRACE
3 1/4"
21 5/8"
MIDDLE BRACE
12 7/8"
16 3/4"
MIDDLE BRACE
LOWER BRACE
COWL SUPPORT 1 x 3 STOCK (2)
32 3/4"
TO FIT COWL
BATTERY SHELF
1/2" PLY
6 3/4"
1/4" SQUARES
20"
14 1/2"
LOWER BRACE
6'
9 1/2"
2 x 4
9"
12"
1/4" LAG SCREW
SPIKE
TOWER BASE BOTTOM VIEW
4 x 4
FIT TO WHEEL
3'
1/2" PLY PLATE
19"
30" TO BACK OF BLADE GUSSET-CRITICAL DIMENSION
1/2" ANCHORS
STAY
CARRIAGE (TOP)
3' MAX.
ANCHOR
COWL SUPPORT HOLE
CONCRETE BLOCKS
CONCRETE FILL
2 1/2" x 1 1/2" ANGLE
1/2"
1/2"
HOLD STAYS CLOSE TO TOWER TO CLEAR BLADES
CARRIAGE (BOTTOM)
1/16" STEEL PLATE
SLOT HOLES FOR CHAIN ADJUSTMENT
22 1/2"
1/4" THREADED ROD (7)
CUT OUTS TO MATCH 2 x 4 DIM.
FLD.
VOLTAGE REG.
N° 35 CHAIN
BAT.
SWITCH
BICYCLE HUB
12 TEETH
FLD.
A. MET.
10 TEETH
JACK SHAFT
GRD.
12-V BATTS.
30 TEETH
ALT
INPUT
FULL-SIZE PATTERN
TO LOAD OR GROUND LEVEL BATTS.
36 TEETH
ALT.
1/4" x 1 1/2"
1 1/2 x 1/4"
1 1/2" I.D.
MATCH TO SUIT HUB
HUB PLATE
2 5/16"
2"
6 1/2"
HUB ASSEMBLY
INNER SHAFT
3/8" ALUM.
3 1/4"
1 1/8"
3 1/4"
SLOT SPIDER & SHAFTS TO FIT OVER HUB PLATE
3/8" STEEL 3" O.D.
HUB COLLAR
1 1/2"
HUB PLATE 3/8" ALUM.
1 1/2" x 1/4" ALUM. TUBE
5'
2 1/2"
2'
2'
6"
WORTMAN FX 60-128 8" CHORD
1" x 1/8" x 3' ALUM.
BLADE SHAFT (3)
3/4" x 3/32" x 2 1/2' ALUM.
"Y" DIMENSION
THICKNESS TAPER
SAW BLADE
HUB USED AS HOLDING FIXTURE
X
WOODEN TIP BLOCKS
SECT. "X"
SAW TABLE
PAPER AND PLYWOOD STACK
Y
TRAILING EDGE
WEDGE 16.25°
20.25°
DEAD CENTER ON BLADE SHAFT CENTER
HORIZONTAL
WORK SURFACE
STATION 1 2 3 4 5
"Y" DIM. 3.79 1.89 1.02 .55 .28
BLADE TWIST TABLE
WEDGE MUST BE REVERSED TO CUT UPPER & LOWER SURFACES

The tower base clamps over four studs protruding from a poured-concrete, or concrete-block pad. Tower stays of steel strapping or cable are optional, but recommended.

Making the blades. Expandable paper honeycomb (covered with fiberglass) simplifies this job. It's available from Windworks (see box on ordering), in blocks the right size for the generator shown in the plans on the facing page. To shape the critical Wortmann FX60-126 airfoil, bolt the honeycomb, in unexpanded form, between two pieces of 3/8" plywood with the axis of the cells running perpendicular to the airfoil chord. Draw the airfoil profile (shown full size on plan) on the upper piece. This will later be the blade tip.

Bolt the stack securely and drill the hole for the shaft. Use a circle cutter. We had the best luck with cutters that did not destroy the material between the center lead and the cutter. An adjustable circle cutter by General, or an Irwin 1R expansive bit (for drill presses) will do the job equally well.

Since the blade shaft is of stepped construction with two different diameters, you must drill the hole for the shaft in two steps. Drill a 3/4" hole halfway through from the stack, then flip the stack over and drill a 1" hole halfway through from the bottom.

Cutting the airfoil. Do this on a bandsaw. A simple trick for cutting automatically puts the proper chord and thickness tapers into the airfoil. Here's how to do it:

Cut a 16.25-degree wooden wedge, sized to match the plywood on the bottom of the stack. Holding the stack with the airfoil outline up, and its leading edge facing you, orient the wedge so its thick edge is to the right. Slip it under the stack, flip everything over, and fasten the wedge in place with flathead screws.

Now move to the bandsaw. Tilt its table 20.25 degrees, and start cutting the airfoil, beginning with the concave underchamber. Start at the trailing edge. When you get to the leading edge, stop. Remove the wedge and reverse it so its thick edge is on the opposite side of the stack. Then continue the bandsaw cut on the rest of the way back to the trailing edge.

Finish by sanding to exact contour, and finally epoxy streamlined root and tip sections of wood to the plywood, and epoxy the plywood to the paper stack.

Next, make the three two-piece shafts. Use 1"-OD with 1/8" wall for the hub ends of the shafts, and 3/4"OD-by-3/32" wall for the shaft tips. These diameters fit the relatively thin airfoil.

Expand the honeycomb on the shaft, using the table on page 104 to set the twist angles. We used the hub to hold the shaft steady, and centered on a sharpened pin through a block at the tip end so the shaft was exactly parallel with the work surface. Note that the "Y" dimensions given in the table use the shaft center as a base. You'll have to add the distance from the shaft center to the work surface if you measure from this base. Pin the end blocks by drilling through them into the shaft, and glue the paper at a number of points to hold the correct angles.

After establishing angles, spray or paint the paper with thinned polyester resin. Thin with acetone before adding the hardener.

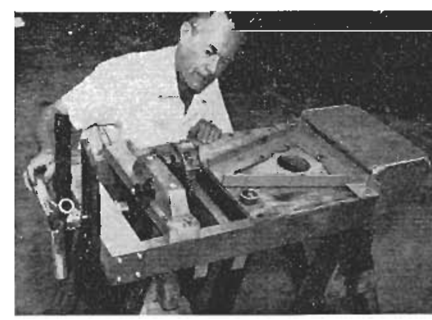
To fiberglass the blades, support each horizontally with the trailing edge down. Lay the cloth over the blade (we used very fine weave Burlington Glass Fabric #1165) and brush on the resin. Where the glass doubles back on itself at the trailing edge, be careful to work out any bubbles. Before the resin sets fully, trim excess glass from the trailing edge. Later sand to a sharp edge. A second covering of glass and several coats of resin give the best surface.

The rotor hub. This is made of 3/8" aluminum plate with three pieces of 1½"-by-¼" wall tubing slotted and welded to it. Blade shafts are also slotted so they can slide into the hub tubing and align on the plate. Each shaft is held by two ¼" bolts crosswise through the hub.

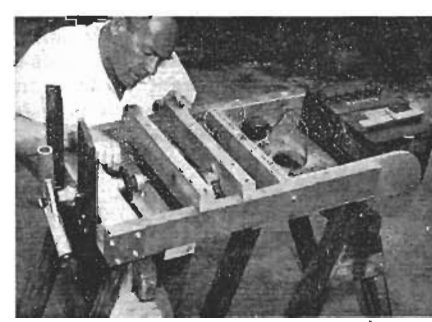
The rotor hub bolts to a 3" steel disk pressed onto a motorcycle rear hub. Make the disk to fit the hub you use. This motorcycle hub mounts in a 4-

[*Continued on page 142*]

Lightweight rotor blades, based on a sophisticated airfoil for highest efficiency, are checked by Midwest Editor E. F. Lindsley who helped Meyer with plans (left).



Underside of alternator/battery carriage is braced with angle iron where it mounts to tower. Note that ammeter is mounted face down so it's visible from the ground.



Top view of carriage shows batteries, in storage tray, and voltage regulator. Batteries serve triple purpose: Energy storage, alternator excitation, counterbalancing.

Streamlined cowling unhinges for easy access to windmill's power train and generating components. Note that nose cone is glued to only one half of the cowling.

How to order expanded paper for rotor blades

The expanded paper used for the rotor blades in the wind generator described here is available from: Windworks, Box 329, Rte. 3, Mukwonago, Wis. 53149. Price for three blocks—enough for one windmill—is $11, postage paid in the U.S.

Wind Generator You Build

[*Continued from page 105*]

by-4 cross-member in the alternator/battery carriage. Drill the cross-member lengthwise for threaded rods, saw it in half through the hub mounting hole. The threaded rods then serve to clamp the hub in place, and hold the carriage together, too.

Power is transmitted through a #35 cycle chain to a bicycle-hub jackshaft. Input to the jackshaft is stepped up 3:1—so is the output to the alternator. Overall stepup is 9:1. Slots in the jackshaft support permit tightening of the primary chain; the alternator pivots to tighten the second chain.

The carriage fits inside a protective cowling hinged to open for access to working parts. Make the cowling in two halves, saber-sawing the three bulkheads and the four main longitudinal braces from half-inch plywood. One side of the cowl bolts to the angle-iron carriage-mount bracing. The second side is hinged to the first, and is pinned shut during windmill operation.

Four 12″ 2-by-4s bolted together and spread progressively toward the base give the tower a parabolic profile. A VW rear-axle section and hub mount on top with the axle shaft and cut-off housing extending downward to seat in wooden blocks inside the tower. We used the emergency brake to lock the windmill in position.

Electrical connections: Tower-to-ground connections are simplest with a cord running up the tower to a wall socket mounted in the cowl. But long periods of unattended running will require fitting some form of slip rings to avoid cord winding. In puffy winds the windmill is unstable in its orientation. This problem can be eliminated by putting a 10-degree bend in each of the blade shafts—near the hub and in the direction of the wind. This stabilizes the windmill in the same way wing dihedral stabilizes a plane.

Costs, weights, final thoughts. As built, the wind generator is easy to move from site to site. The tower weighs about 160 pounds; the carriage, cowling, and rotor add another 125 pounds. Our total cost for materials and parts was $182, not including the alternator and batteries.

This prototype design was originated by Windworks, a research group devoted to development of nonconventional energy sources. We recognize that, as with any prototype, simplifications and substitutions might be made to reduce costs and labor.

We offer these plans as a guideline and welcome any comments (address on page 105). PS